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Project Summary

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Comparative Study of Air Classifiers

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This paper presents the results of an extensive air classifier field test program conducted for the U.S. Environmental Protection Agency (EPA). Methods of testing, criteria for evaluation, operating conditions, and assessment of air classifier performance are described. Topics germane to the design and operation of air classifiers are also covered. Test results show that air classifiers performances can be compared under equitable conditions. The comparisons presented here permit judgements about the relative performances of air classifiers and the tradeoffs that must be considered when describing air classifier performance.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Seven air classification systems with nominal throughputs ranging from 4 to 91 Mg/hr have been field tested and evaluated under a 2-year program sponsored by the U.S. Environmental Protection Agency (EPA).[1] The purpose of the testing program was to characterize and compare the operation and performance of air classifiers located in the field. During the course of the work, characterization criteria were developed that enabled the comparison of all air classifiers on an equivalent basis. Because the best air classifier performance existed only for sufficiently dilute air/solids mixtures within the air classifier column, the air/solids ratio was chosen as the means for establishing the performance parameters. For each set of operating conditions, the performance parameters varied relatively little when the air/solids ratio was greater than a critical value, that value being defined by the point where the constant light fraction split fell off by 1 percent. (Constant light fraction split is defined as that value of the light fraction split that does not change at a given air flow and is independent of the air/solids ratio.) The unvarying nature of material characteristics above the critical air/solids ratio has been documented previously.[2]

The seven air classifiers tested in this study, their locations, and their general descriptions are given in Table 1. (Further details concerning the geometrical configuration of the air classifiers are available in the final report to EPA.)

An examination of some of the key characteristics of the solid waste encountered during the air classifier testing program shows the importance of normalizing the performance parameters in terms of the air classifier infeed composition. Wide variations exist in the waste characteristics from site to site. For example, the paper and plastic content of the infeed to the Los Angeles air classifier average 30.2 percent, whereas it exceeded 50 percent at the other six air classifiers.

Table 1. *Summary of Air Classifiers Tested*

Site	Type of Air Classifier	Design Throughput (Mg/hr)	Cross Sectional Shape of Column
Tacoma, WA	Horizontal	73	Rectangular
Baltimore Co., MD	Vertical	91	Circular
Richmond, CA	Vertical	4	Rectangular
Ames, IA	Vertical	45	Rectangular
Los Angeles, CA	Vertical	4	Rectangular
Akron, OH	Vibratory, inclined	64	Rectangular
Pompano Beach, FL	Vibratory, inclined	6	Rectangular

Two of the air classifiers were fed shredded and screened solid waste (Ames and Pompano Beach), and the other five air classifiers received processed waste that had been shredded only. Consequently, normalizing the performance parameters in terms of the infeed composition was essential to allow comparisons among the air classifiers. Note that the ash content of the screened air classifier feed material at Ames and Pompano Beach ranged from 13 to 14 percent, whereas it was 31 to 40 percent at the five sites not employing screening before air classification.

Abbreviations for terms specific to air classifier performance and operation are listed in Table 2.

Table 2. *Air Classification Abbreviations*

Abbreviation	Term
A/S ratio	Air/solids ratio
L F	Light fraction
H F	Heavy fraction
Fe	Ferrous metals
NonFe	Nonferrous metals
PP	Paper and plastic

Test Procedures and Methods of Analysis

For each air classifier, the test program consisted of collecting samples of heavy and light fractions under a specified set of operating conditions. Samples were collected at three discrete air flow settings (high, medium, and low) over as wide a range of material flowrates as was possible within the physical constraints imposed by the facility or the air classifier system. One of the three air flow settings was the operating mode used by the plant under normal processing conditions. The reason for selecting three air flows and a full range of throughputs is that no generally accepted definition exists for an optimum air classifier operating condition or setpoint in the industry. In addition, manufacturers' data or recommendations as to an air classifier setpoint are not typically available.

Five samples of heavy and light fractions were collected simultaneously for each air flow setting. Before each actual test run, a dry run was used to determine the time intervals needed to collect simultaneous samples of heavies and lights. Particle size of the heavy and light fractions was used to determine the quantity of material to be used for the size distribution and composition analyses. Size distribution and composition analyses were performed with subsamples from the heavy and light samples collected for mass flowrate measurements. The latter samples generally ranged from 10 to 50 kg. Samples for the size distribution and composition analyses ranged from 2 to 10 kg.

The general procedure involved setting a particular airflow through the classifier, by varying the rpm of the air classifier fans or adjusting a damper. Subsequently, samples of heavy and light fractions were collected simultaneously for a number of different material feedrates to the air classifier. Samples of heavy and light fractions were collected from conveyors downstream of the classifier. These samples served the dual purpose of allowing calculation of the flowrate of the heavy and light fractions and providing the material from which representative samples were chosen for later laboratory analyses. All material was completely removed from a given length of conveyor belting, thus alleviating the problem of stratification of components in the flow stream (which might have skewed the results if only grab samples had been collected).

Laboratory analysis consisted of air drying, screening, and manually sorting the light and heavy fractions—except for the Ames air classifier testing, in which it was only possible to collect infeed and heavy samples. In addition, heating value determinations and ash analyses were carried out on light and heavy fractions collected at each site following the procedures proposed by the ASTM for refuse derived fuel No. 3 (RDF-3). Both manual and mechanical screening were used to determine the size distribution of the samples. Size distribution analyses were carried out to determine the amount of fines (minus 14 mesh) in the heavy and light fractions and also to provide a quantitative means of describing the particle size of the shredded air classifier feed material. Manual sorting of the samples consisted of separating ferrous, paper and plastic, and nonferrous components from the heavy and light fractions. Composition and size data were used subsequently to develop the characterization parameters.

Also as part of the test program, both air flow and system power requirements were measured for each operating setpoint (i.e. air flow setting).

Results and Discussion

Operating parameters determined for each air classifier are summarized in Table 3. Data are shown for each of the three air flow settings used during the test program at each site. The volumetric air flows corresponding to the high, medium, and low air-flow settings are reported in the final report.

Critical throughputs are reported in Table 3 instead of the maximum tested feedrates because the air classifiers were operating in a choked condition for feedrates greater than the critical throughput value. Consequently, they were not exhibiting their best performance for each air flow setting.

The air classifier performance parameters were calculated from data for which the air/solids ratios exceeded the critical value. For reasons previously

Table 3. *Summary of Operating Parameters*

	Air Flow Setting	Critical Specific Energy KWh/mg	(KWh/t)	Critical Column Loading (Mg/hr)/m	(tph/ft)	Critical A./S Ratio	Average Column Velocity (m/s)[b]	(fpm)	Heavys Throat (m/s)[b]	Constant L.F. Split (%)	Critical Throughput Mg/hr	(tph)
Tacoma	High	≤1.1	≤(1.0)	≥46.0	≥(4.7)	≤1.6	17.29	(3,404)	NA	80	≥120	≥132
	Medium	1.0	(0.9)	37.2	(3.8)	1.7	15.26	(3,005)		75	99	109
	Low	0.9	(0.8)	36.2	(3.7)	1.7	14.36	(2,826)		62	95	104
Baltimore	High	5.9	(5.4)	9.8	(1.0)	3.5	8.18	(1,610)	NA	80	36	40
	Medium	9.0	(8.2)	5.9	(0.6)	5.5	7.31	(1,440)		78	21	23
	Low	13.2	(12.0)	3.9	(0.4)	7.5	6.35	(1,257)		77	13	14
Richmond	High	5.1	(4.6)	8.8	(0.9)	5.1	6.38	(1,257)	NA	84	3.3	3.6
	Medium	9.2	(8.4)	4.9	(0.5)	6.8	4.48	(881)		78	1.7	1.9
	Low	9.4	(8.5)	2.0	(0.2)	8.5	3.43	(676)		61	0.9	1.0
Ames	High	≤7.6	(6.9)	≥18.6	≥(1.9)	≤2.6	11.42	(2,248)	NA	86	≥21.0	≥23.1
	Medium	≤7.6	(6.9)	≥17.6	≥(1.8)	≤2.5	10.74	(2,115)		78	≥20.5	≥22.5
	Low	≤4.6	(4.2)	≥27.4	≥(2.8)	≤1.5	11.52	(2,268)		88	≥31.8	≥35.0
Los Angeles	High	8.2	(7.5)	8.8	(0.9)	6.6	11.29	(2,223)	NA	89	3.2	3.5
	Medium	9.5	(8.6)	7.8	(0.8)	5.9	8.75	(1,722)		86	2.8	3.1
	Low	11.4	(10.4)	4.9	(0.5)	5.6	6.19	(1,218)		82	2.0	2.0
Akron	High	14.1	(12.9)	16.7	(1.7)	6.4	26.21	(5,160)	18.41	96	19.9	21.9
	Medium	10.5	(9.6)	21.6	(2.2)	4.7	24.70	(4,862)	18.46	95	26.7	29.4
	Low	11.4	(10.4)	20.6	(2.1)	4.6	22.36	(4,401)	16.05	93	24.9	27.4
Pompano Beach	High	11.2	(10.2)	11.8	(1.2)	5.6	15.51	(3,055)	3.33	86	4.4	4.8
	Medium	15.0	(13.6)	8.8	(0.9)	6.3	12.89	(2,538)	2.20	86	3.3	3.6
	Low	14.6	(13.3)	8.8	(0.9)	5.2	11.03	(2,182)	1.97	84	3.4	3.7

[a] t = ton, tph = ton per hour.
[b] Air velocity in the vicinity of the heavy fraction discharge point of the Triple S air classifiers.
[c] NA = not applicable.
[d] Re-adjustment of the air bleed of the air classifier caused an increase in the column velocity despite a decrease in the air flow control setting.

discussed, the normalized values are the significant parameters. Because of the differing characteristics of the air classifier infeed material among the various sites, the absolute values for the performance parameters are only of value when they are used to judge individual air classifier performance and not to compare air classifiers among different sites. In addition, the use of the absolute values for evaluating air classifier performance at a particular site presupposes that the waste composition does not vary for the duration of the tests—a questionable assumption.

Many comparisons and conclusions can be drawn from the data. For example, the data show that approximately 70 to 99 percent of the input energy content can be recovered in the light fraction. In addition, for most air classifiers near their normal operating points, recovered energy ranges from 90 to 99 percent. As a second example, the percentage of paper and plastic in the heavy fraction ranged from 0.8 to 42.8 percent, excluding the Pompano Beach data, which was skewed because of the significant amount of preprocessing of the waste before air classification.

The light fractions obtained in Ames and Pompano Beach have relatively high heating values. This result may be due to the composition of the raw waste and/or the effect of screening before air classification. The light fraction obtained in Los Angeles also has a relatively high heating value, but it cannot be attributed to screening, since that unit process was not employed at the site. Instead it is partly a consequence of the air classifier feed at Los Angeles which also has a relatively high heating value.

To establish criteria for air classifier evaluation, two key ratios can be used: recovered paper and plastic/retained fines, and recovered energy/retained ash. The first ratio (recovered PP/retained fines) could be used to determine optimum air classifier performance for selectively separating paper and plastic components from fine inorganic contaminants (for instance, when fiber recovery is the intent of a resource recovery process). On the other hand, for recovery of a refuse derived fuel, the ratio of recovered energy (RE) to retained ash (RA) is significant and has been chosen for use in this study as the key criterion for establishing the performance characterization of the seven air classifiers that were tested.

The selection of the RE/RA ratio as the key criterion is based on the fact that both recovered energy and retained ash in the light fraction are normalized on an infeed basis, thus eliminating the effects of variation in refuse composition. Large values of this ratio imply that an air classifier is recovering in the light fraction a significant percentage of the energy available in the infeed material and simultaneously dropping out into the heavy fraction a significant percentage of the ash-carrying components.

If the maximum values of RE/RA for each air classifier are chosen as the criterion (or premise) for determining the optimum operating point for recovery of a high-quality RDF, then other performance parameters can also be chosen for comparison based on the air flow setting that results in the maximum value of RE/RA for each air classifier.

A comprehensive assessment can be made of the various air classifiers under their respective optimum air setting for RDF recovery (Table 4). Included are the judging criteria and the key parameters used to quantify each judging criteria. The first three parameters (specific energy, column loading, and RE/RA) were determined from field measurements. The last two parameters (system complexity and 1980 costs) are of a qualitative nature. The judgment of system complexity was based on visual observation of the total air classifier system (including number of conveyors, blowers, cyclones, mechanical equipment required) the engineering and structural complexity, and an engineering judgement of the degree and type of control necessary to maintain the air classifier in operating order. Costs were determined by escalating reported capital costs (10 percent per annum) to 1980 levels and dividing them by the

Table 4. *Operating and Performance Parameters of Seven Air Classifiers for RF Recovery*

	Judging criteria and key parameter				
	Energy Requirement	Unit Size	RDF Quality	System Complexity	Cost[a]
			Avg. Recovered Energy		
Air Classifier	Specific Energy (KWh/Mg)	Column Loading (Mg/hr) m	Avg. Retained Ash (Ratio)	Design Simplicity (Ranking)	1980 Cost Basis ($Mg/hr)
1. Tacoma	(0.9)	(36.2)	(1.5)	6[b]	$ 5,800
2. Baltimore	(5.9)	(9.8)	(1.8)	3	12,600
3. Richmond	(5.1)	(8.8)	(2.3)	1	4,300
4. Ames	(7.6)	(18.6)	(2.0)	4	14,000
5. L.A.	(11.4)	(4.9)	(1.9)	2	8,200
6. Akron	(11.4)	(20.6)	(1.3)	6	6,600
7. Pompano Beach	(11.2)	(11.8)	(1.5)	5	6,200

[a] *Estimated capital cost (equipment and engineering) for air classifier system; costs exclude operating and maintenance expenses. Mg/hr = throughput at the critical A/S ratio.*

[b] *1 = simplest system; 6 = most complex system.*

critical throughput for each air classifier at its optimum air flow setting.

Conclusions

The testing and performance characterization of seven air classifiers has shown the ranges of operating conditions and performance that can be expected for each air classifier. In addition, methods have been presented for comparing different types of air classifiers operating under different air and material flows and handling shredded refuse of differing composition. No absolute means exists for comparing air classifier performance. As the data in Table 4 show, positive and negative points exist for all air classifiers. But it is now impossible to judge air classifier performance on a relative basis if the judging parameters are judiciously chosen so as to allow an equitable comparison (i.e., normalization of the system outputs to eliminate the effect of varying infeed composition). The methods and data presented here should prove useful in the evaluation of other air classifiers.

Since the field tests covered a number of different air classifiers, analysis of the test data can establish quantities of waste constituents that should be of interest to the resource recovery industry— for example, the percentages of ferrous metals, nonferrous metals, retained fines, and paper and plastic in the light fraction. Results of all seven field tests taken collectively enable an overall (or average) value of certain parameters to be calculated. Such average values subsequently can be used for calculation of mass and energy balances on an air classifier system. For example, the mass fraction of nonferrous metals in the light fraction can be computed from the mass fraction of nonferrous metals in the air classifier feed and the percentage of nonferrous metals retained in the light fraction.

The testing of these air classifiers makes apparent the need for a standard method of testing and evaluation for the resource recovery industry. Such standards would not only allow performance comparisons among different air classification systems, but they would also establish the correct operating settings for producing a specified output. Presently little control is exercised over the air classification process. Consequently, the quality of the RDF output often suffers. As with most resource recovery processes, air classification has yet to progress from an art to a controlled process.

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References

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2. Savage, G., Diaz, L and Trezek, G., "Performance Characterization of Air Classifiers in Resource Recovery Processing," *Proceedings of the 1980 National Waste Processing Conference: Resource Recovery Today and Tomorrow*, American Society of Mechanical Engineers, New York, May 1980.

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The complete report, entitled "Comparative Study of Air Classifiers," (Order No. PB 82-106 121; Cost: $22.50, subject to change) will be available only from:

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